

CHAPTER 1

INTRODUCTION TO RELIABILITY

1-1. Purpose

The purpose of this technical manual is to provide a basic introduction to and overview of the subject of reliability. It is particularly written for personnel involved with the acquisition and support of Command, Control, Communication, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) equipment.

1-2. Scope

The information in this manual reflects the theoretical and practical aspects of the reliability discipline. It includes information from commercial practices and lessons learned over many years of developing and implementing reliability programs for a wide variety of systems and equipment. Although some theory is presented, it is purposely limited and kept as simple as possible.

1-3. References

Appendix A contains a complete list of references used in this manual.

1-4. Definitions

The key terms used in this TM are reliability, mission reliability, basic reliability, mission, function, failure, and probability, among others. Definitions are found in the glossary.

1-5. Historical perspective

Reliability is, in one sense, as old as humankind's development of tools, using tools in the broadest sense to include all types of inventions and products. No one has ever set out to make a tool that doesn't work well over time (a very fundamental way of viewing reliability is the ability of an item to perform its function over time). Until the 20th century, however, people did not consciously "design and manufacture for reliability, and reliability was not a known discipline. It was during World War II that reliability as a distinct discipline had its origins. The V-1 missile team, led by Dr. Wernher von Braun, developed what was probably the first reliability model. The model was based on a theory advanced by Eric Pieruschka that if the probability of survival of an element is $1/x$, then the probability that a set of n identical elements will survive is $(1/x)^n$. The formula derived from this theory is sometimes called Lusser's law (Robert Lusser is considered a pioneer of reliability) but is more frequently known as the formula for the reliability of a series system: $R_s = R_1 \times R_2 \times \dots \times R_n$.

1-6. Importance of reliability

Reliability has increased in importance over the past 30 years as systems have become more complex, support costs have increased, and defense budgets have decreased. Reliability is a basic factor affecting availability, readiness, support costs, and mission success. Research into how things fail, the development of probabilistic approaches to design, an understanding of the distributions of times to failure, and other advances have made reliability a science.

- a. *Applies to all products.* Although reliability grew out of a military development program, reliability has become an essential design parameter and performance measure for nearly every product and system, commercial and military. Thus, companies developing valves and other components and equipment used to control the flow of petroleum from the sea bottom, machinery used to manufacture products, medical devices, and commercial airliners all have a vested interest in designing and producing for reliability.

b. *A fundamental performance parameter.* Customers may not use the term reliability when specifying requirements or measuring the performance of their products and systems. Instead, they may have goals such as high availability, high readiness, low life cycle costs, long service life, and so forth. As we will see, achieving these goals begins by designing and producing for reliability, a fundamental performance parameter.

(1) Reliability is a basic factor in mission success. Military commanders are concerned with mission success. The reliability characteristics of a system are used in all operational planning. Fleet sizing, manning requirements, operational doctrine, and strategic targeting all rely directly or indirectly on the reliability of the system and hardware involved.

(2) Reliability is a basic factor driving support requirements. The more reliable a system, the less need for support. If reliability could be taken to the extreme, 100% reliability (zero failure rate), a system would never require any maintenance. No spares would need to be bought nor would any test equipment or maintenance facilities be necessary. The only maintenance people who would be needed would be those involved with servicing, cleaning, and other non-failure related tasks. Understanding the reliability characteristics of a system, its subsystems, and components is essential in using a Reliability-Centered Maintenance approach for developing a preventive maintenance program. For information on applying RCM to C4ISR facilities, see TM 5-698-2.

(3) Reliability affects safety. Although safety focuses more on preventing failures from causing serious consequences to human operators, maintainers, and bystanders, and reliability focuses more on preventing the failures themselves, safety and reliability are related. Many of the analyses performed for safety are similar to, can use the inputs from, or provide information for many reliability analyses.

(4) Reliability is one of the three factors determining availability. A perfectly reliable system would always be available for use. The availability would be 100%. Given that perfect reliability is impractical and unachievable, availability will always be less than 100%. However, availability is also affected by two other factors: the speed at which a repair can be made (a function of design referred to as maintainability), and the support system (number of spares, ability to get spares to where they are needed, etc.). If repair could be conducted in 0 time (another impracticality), availability would be 100%. Thus, availability, like reliability is bounded – it cannot be greater than 100% or less than 0. Different combinations of reliability and maintainability can yield the same level of availability. See appendix B.

(5) Reliability significantly affects life cycle costs. As already stated, reliability affects support requirements, and thereby support costs. The higher the reliability, the lower the support costs. However, achieving high levels of reliability requires investment during acquisition. For instance, high reliability can require hi-rel parts, require special production lines, close quality control, screening of all parts, and carefully controlled production environments. Therefore, trades must be made between cost of ownership and cost of acquisition in order to keep total cost, life cycle cost, as low as possible consistent with mission requirements.